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ACCIDENT EXPERIENCE AND COSTS IN COLORADO METAL MINES

BY

E. H. DENNY AND E. A. ANUNDSEN

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DEPARTMENT OF COMMERCE - BUREAU OF MINES

ACCIDENT EXPERIENCE AND COSTS IN COLORADO METAL MINES[1]

By E. H. Denny[2] and E. A. Anundsen[3]

The prevalence of mine accidents in metal and coal mining in the various States has been responsible for detailed studies of accident causes and costs by the United States Bureau of Mines. Several reports[4] of the Bureau have recently appeared that deal with the cost of accidents. In addition, the Bureau publishes complete statistics yearly on the fatal accidents occurring in metal mines, coal mines, and quarries, also giving much data on nonfatal accidents.

It is felt that any figures presenting the true direct compensation and medical costs of mine accidents will serve to emphasize to mine operator and miner the economic as well as the humanitarian importance of the lessening of accidents. The present cost of compensation insurance is a considerable part of the labor cost; the tendency is toward legislative action with more liberal compensation payments for accidents to workers. Insurance companies in some cases are asking higher rates for compensation insurance, and state insurance funds are scrutinizing more carefully the ratio of premiums and losses for every branch of industry carried. Obviously, the most feasible means of keeping mine compensation insurance rates at their present level or reducing them is to decrease the number and severity of accidents.

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1 The Bureau of Mines will welcome the reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6713."

2 District engineer, U. S. Bureau of Mines, Denver, Colo.

3 Associate mining engineer, U. S. Bureau of Mines, Denver, Colo.

4 Ash, S. H., Accident Experience and Cost of Accidents in Washington Coal Mines: Inf. Circ. 6529, 1931, 18 pp.
Murray, A. L., and Harrington, D., Accident Experience of the Coal Mines of Utah for the Period 1918-1929: Inf. Circ. 6530, 1931, 26 pp.
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Fene, W. J., Accident Experience and Cost in Pennsylvania Anthracite and Bituminous Mines, 1926-1930: Inf. Circ. 6618, 1932, 29 pp.
Cash, F. E., Accident Experience and Cost in Tennessee Coal Mines: Inf. Circ. 6664, 1932, 8 pp.
Herbert, C. A., Ten Years of Fatal Accidents and Two Years of Accident Costs in Indiana Coal Mining: Inf. Circ. 6672, 1932, 12 pp.

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This report discusses the cost and causes of Colorado metal-mine accidents in the period 1926 to 1930, inclusive. These accidents occurred in mines scattered over many counties. Numbers of them occurred at old reopened mines, first worked many years ago. Most of the operating mines are small in number of persons employed.

In 1930, John T. Joyce, commissioner of the Colorado Bureau of Mines, reported 361 mines or groups of mines, including 12 placers, located in 31 counties as operating. These operations gave 1,000,669 days of employment, which is equivalent to about 9 men at each operation working 290 days per year. Colorado reports more operating mines than do States with much larger metal production and many more men employed, as, for example, Nevada, Utah, Montana, Arizona, Michigan, and Minnesota. According to C. W. Henderson's chapter in Mineral Resources of the United States for 1930, Colorado metal mines in 1930 had production amounting to $13,265,701 in gold, silver, lead, and copper, and also more than $3,000,000 in tungsten, molybdenum, vanadium, iron, and manganese.

SUMMARY

Important facts brought out in this study of Colorado metal-mine accidents include the following:

1. The direct cost of 5,510 Colorado metal-mine accidents in a 5-year period in compensation, medical, hospital, funeral, and dental benefits was approximately $1,000,000, of which about 83 percent was compensation.

2. Each compensable case averages for compensation $464 and for medical attention $77.

3. The major compensation cost is that of fatalities, permanent total disabilities, and permanent partial disabilities. Fifteen permanent total disabilities have cost or probably will cost an average of over $18,000 each.

4. Compensable injuries involving no permanent disability cost only about $55 each in compensation but $54 in medical charges.

5. No-lost-time injuries, of which 1,949 were reported, cost about $7.50 each for medical and dental care.

6. A comparison of accident-frequency rates both as to fatal and nonfatal injuries shows that Colorado has one of the poorest records of the metal-producing States as far as fatalities are concerned and only a mediocre rate as far as nonfatal injuries are concerned.

7. Colorado metal mines employ a relatively small number of men per mine and many of the properties are old. Usually, the larger property can make a better safety record because of its organization and financial resources than can a small one; nevertheless, many small mines have enviable safety records and the writers believe that Colorado's metal mines can have them also.

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8. The causes of accidents in Colorado metal mines are much the same as in other States, with falls of rock or ore, timber and hand tools, drilling, and haulage causing the larger percentages of accidents. Accident reports indicate in numerous cases that accidents could have been prevented, if reasonable precautions had been taken.

9. The approximately $1,000,000 direct cost of accidents for a 5-year period is probably only a fraction of the indirect and hidden costs of accidents which one authority puts at four times the direct cost.[5] This $1,000,000 direct cost does not include the cost of administration of the State fund nor that of other insurance carriers. The Colorado Industrial Commission states that the cost of writing insurance by the Colorado State Fund was 7.1 percent of the premiums received.

METHODS EMPLOYED IN ACCIDENT STUDY

Through cooperation of the Colorado Industrial Commission, engineers of the United States Bureau of Mines were given access to the individual reports of the Commission for all metal-mining accidents. The workman's compensation act of Colorado provides (section 30) that--

> Every employer shall keep a record of all injuries, fatal or otherwise, received by his employees in the course of their employment. Within 10 days after the occurrence of an accident resulting in personal injury, a report thereof shall be made, in writing by the employer to the Commission, upon forms prescribed by the Commission for that purpose.

These reports are in most cases fairly complete and give such information as the cause of the accident, length of disability if any, compensation paid, and in many cases the medical and hospital costs. The information in this report is based on examination of all individual accident reports for metal mines for the period 1926 to 1930, inclusive. It is believed that it furnishes a practically complete and accurate record of the number of accidents and compensation payments classified as to direct causes. In a few continuing cases of severe injuries it was necessary after consulting Commission officials to estimate the future compensation payments to be made. In cases of permanent total disability a life expectancy table (see p. 54, Workmen's Compensation Act of Colorado, Expectancy Table C.L. Sec. 6537) was used in computing compensation payments. Medical, hospital, funeral, and dental costs were available in all cases when paid by the state--that is, for companies insuring with the Colorado State fund and not insuring "exmedical." Self-insurers and companies insuring with commercial insurance companies in many cases do not report medical or hospital costs to the Commission. From the 3,055 cases for which medical costs were available an estimate of the total medical cost for all cases was made.

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5 Heinrich, H. W., Cost of Industrial Accidents to the State, the Employer, and the Man: Reprint of address before 17th annual meeting, Internat. Ind. Accident Boards and Commissions, Wilmington, Delaware, Sept. 22-26, 1930, p. 8.

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As used in this report, the number of days lost from accidents involving no permanent partial or total disability is the number of days lost from the day of disability to time of return to work, including Sundays and holidays. If the men did not report back to the job the doctor's estimate of time lost from accident is used. For permanent partial and total disabilities and fatalities, the amount of awards varies in the several States, and to make figures comparable on days lost, the table for weighing industrial accident disabilities recommended by the Association of Industrial Accident Boards and Commissions and printed herein (Table 8) was used. Thus, a fatality or permanent total disability is rated at 6,000 days lost time and other permanently disabling injuries are rated proportionately.

The figures given include, for the period 1926 to 1930, inclusive, all metal-mine accidents in Colorado both on the surface and underground, a few accidents occurring in clay mines, and a very few gold-dredging accidents; they do not include any quarry, mill, smelter, coal-mine, or railroad-tunnel accidents. The compensable accidents listed are those for which the period of disability lasted longer than 10 days from the day the injured employee left work. They include a few cases in which no compensation was paid because of inability to locate the one-time injured man or in several fatal cases because of no dependents. The noncompensable cases include all cases reported where the injured person was disabled for 10 days or less; numerous "no time lost" accidents are included, most of which involve definite medical cost.

COST OF ACCIDENTS

From 1926 to 1930, inclusive, according to this study of the Industrial Commission's records, there were in and about Colorado metal mines 1,761 accidents involving a loss of more than 10 days time each and 3,749 accidents involving loss of time of 10 days or less each, a total of 5,510 accidents. For these 1,761 compensable accidents a total of $817,505.88 compensation has or will be paid and there was an estimated medical, hospital, and funeral cost, based on the actual cost of 787 compensable cases and 2,268 noncompensable cases of $135,052.42 for the more than 10-day lost time cases and of $32,452.79 for the noncompensable cases. This is a total direct cost of $985,011.09.

For each compensable accident, including fatalities, there was an average compensation cost of $464.23 and an average medical (including hospital and other charges) cost based on the above estimates of $76.69; for each noncompensable case there was an average medical cost of $8.66. The average direct cost of each of the 5,510 mine accidents reported (compensation, medical, hospital, funeral) was $178.77.

A large portion of the total compensation cost of Colorado metal mine accidents is due to fatalities, permanent total disabilities, and permanent partial disabilities. Thus, 96 fatalities cost in compensation $246,014.21 or an average of $2,562.65 per fatality. It is estimated that 15 permanent total disabilities will cost $271,009 in compensation, or that these men now totally blind or with broken backs will receive on the basis of $14.00 or

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less per week an average of $18,067.23 each; 236 permanent partial disabilities, many involving such serious loss as that of an eye, cost $222,045 in compensation or an average of $940.87 each. The total compensation cost of the 347 fatalities and of permanent total and partial disabilities is $739,068, leaving a compensation cost of $78,438 for the 1,414 remaining compensable injuries involving no permanent disability. The average compensable case involving no permanent disability, therefore, costs only $55.47 in compensation. Assuming $14 weekly compensation payments with the 10-day waiting period for which no compensation is paid, the average injured man receiving compensation and having no permanent loss of members gets in compensation for 30 days of disability $55.47 of $1.85 per day. It is only fair to state, however, that some companies continue men on full or half salary or wages during the period of disability, such payments not being included in the above compensation records.

These 1,414 compensable injuries involving no permanent disability had an estimated medical cost, based on the actual recorded cost of 567 of these cases, of $75,995.49 or approximately $53.75 per injury. The doctors, therefore, fare nearly as well as the patients on compensation cases involving no permanent disability.

Of the 3,749 noncompensable cases recorded, 1,949 were reported as involving no loss in time. Nevertheless, there was an appreciable medical cost for these cases. Costs were available for 1,323 cases in total amount $9,886.72. This is an average of $7.47 medical cost per each no-lost-time case. A considerable amount of this cost was due to dental work necessitated by the injuries.

The time lost by the individual injured in mine accidents is of interest. In the 5,510 accidents reported there were 972,265 days lost or an average of 176.5 days per accident; 1,761 of these accidents were compensable and the average days lost for each compensable case was 547.5 days. It should be remembered that in these calculations a permanently disabling accident or a fatality is rated by the scale of time losses given in Table 8; thus, a loss of leg below the knee is equivalent to 3,000 days or a fatality 6,000 days. Of the accidents 3,749 were noncompensable, and the average time lost in these, including 1,949 no lost-time accidents, was 2.2 days. These data are given in detail in Tables 3 and 4.

CAUSES OF ACCIDENTS

The proximate causes of accidents according to the classification of the United States Bureau of Mines and the Colorado State Bureau of Mines are also given in Table 6 with the average loss of time from each cause. However, some comment on these proximate causes is worth while in connection with the more detailed information available in the Commission's individual reports. The term "proximate cause"[6] is used because often many factors contribute to an accident such as condition of surroundings or equipment, illumination or lack thereof, discipline, supervision, state of mind of the injured at time of accident, fatigue, ill health, lack of mental alertness, carelessness,

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recklessness, loose clothing, and possibly other influences. Sometimes, one or more of these factors may be of more importance in injury causation than that ascribed under any of the usual headings.

Cause 1: Falls of rock or ore from roof or wall.- Accounts for 987 accidents. Here, as is usual in mines, is the largest cause of both serious and slight injuries and in these tabulations of 18 per cent of all Colorado mine accidents. In the Commission's reports appeared evidence in many cases of insufficient testing of roof, insufficient barring down of loose rock, insufficient supervision and discipline, insufficient timbering, and carelessness. Falls of rock while drilling were particularly frequent. In many cases protective hats or shoes would have minimized the injury.

Cause 2: Rock or ore while loading at working face.- Accounts for 388 accidents or 7 percent. Accidents from this cause included rocks rolling down muck pile, strains from lifting and shoveling, injuries to feet, hands, and eyes in loading operations.

Cause 3: Timber or hand tools.- Accounts for 712 accidents or 13 percent. Accidents included strains from handling timber and injuries of all sorts from hand tools. Sharp picks and axes and good handles for tools would have eliminated some of these accidents. Use of goggles would have prevented many accidents from flying particles of rock and steel.

Cause 4: Explosives.- Accounts for only 59 or 1 percent of all accidents, but over 2,731 days were lost per compensable explosive accident. Several of these accidents were fatal. Even more serious, some were cases of total loss of eyesight, only slightly atoned for by award of compensation for life. There was much evidence of careless practice in the handling of explosives and detonators and insufficient examination or working places for missed shots.

Cause 5: Haulage.- Accounts for 609 accidents or 11 percent of all accidents. Lack of clearance and poor track have contributed to some of these accidents.

Cause 6: Falling down chute, raise or stope.- Accounts for 219 accidents or 4 percent of all accidents. It is also noted that the severity rate (526 days lost per accident) is particularly high. Despite frequent assurances of mine officials and miners that they are so familiar with their traveling ways that accidents do not happen, it is evident from these figures that men do fall down chutes, raises, and stopes and receive serious injuries. Observations made in some mines lead to the conclusion that it is remarkable that many additional such accidents do not happen.

Cause 7: Run of ore from chute or pocket.- Accounts for 354 accidents or over 6 percent of all accidents. The subject of chute gates is thoroughly

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6 U. S. Bureau of Labor Statistics, Standardization of Industrial Accident Statistics: Bull. 276, 1920, 103 pp.

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discussed in United States Bureau of Mines Information Circular 6495, entitled "Underground Chute Gates in Metal Mines" (Aug. 1931). In some cases better chute gates would prevent injury to men drawing rock or ore.

Cause 8: Drilling.- Accounts for 612 accidents or over 11 percent of all accidents. Accidents from drilling are frequent but less severe than numerous other causes of accidents. A frequent item in Colorado accident reports is "piece of rock in eye while drilling," and particularly while collaring a hole; the use of goggles would have prevented such accidents. Other frequent occurrences are strains while handling drill, and fall of drill or drill steel on person; in many cases use of "safety" shoes would prevent accidents of this type.

Cause 9: Electricity.- Accounts for only 9 underground accidents recorded as due to electricity. This low number is largely due to the present limited use of electricity in Colorado metal mines, and particularly the little use of trolley locomotives. In mines in other States, electrical contact hazard and fire hazard have taken their toll. All electrical installations should be made with a careful regard to fire and contact hazards.

Cause 10: Machinery.- Accounts for 66 accidents or a little over 1 percent of all accidents. The severity rate of such accidents is quite high and unquestionably proper guarding of machinery would have prevented many injuries from this cause.

Cause 12: Suffocation from natural gases.- Although few accidents (14) were recorded from asphyxiation during the 5-year period, yet Colorado has had over 40 mine fatalities from this cause. The importance of testing mine air, particularly when entering abandoned metal mines, with a candle or carbide lamp must be held in mind. Many abandoned mines may be filled with air mixtures deficient in oxygen, the breathing of which will suffocate the victim almost instantly.

Causes 14 and 26: Stepping on nails, underground and on the surface.- Accounts for 151 accidents and about 3,500 days total loss of time. The little upturned nail has cost over $2,600 in compensation and over $1,300 in doctors' bills; "good housekeeping" in and about the mine would have prevented most of these accidents.

Causes 16 to 20: Shaft accidents.- Accounts for 124 accidents. These accidents are relatively infrequent but severe, as might be expected in the case of breakage of cables, cage troubles, and objects falling down shafts; many of these accidents are preventable if readily available precautions are taken.

Causes 22 to 30a: Surface accidents.- Accounts for 909 or about 16 percent of all accidents. The high severity rate of accidents in connection with railroad cars and locomotives is noteworthy. Electricity (cause 28) also has an even higher severity rate due to several fatalities from electrical contact. Falls of person, hand tools, and handling material account for over half of the surface accidents.

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Cause 30b: Other causes.- This miscellaneous classification includes fatalities from aerial tramways and from snowslides, also from burns received on the surface from handling carbide lamps.

ACCIDENT FREQUENCY AND SEVERITY RATES

Accident frequency and severity rates in Colorado metal mines have been calculated (see Table 7) from the lost-time accidents listed in the Colorado Industrial Commission reports and from the number of days of employment given in the Colorado State Bureau of Mines annual reports. Calculations show that over the 5-year period 1926 to 1930, inclusive, there was an annual average of 163 lost-time injuries, including 4.4 fatalities per thousand 300-day workers. In other words, approximately 159 of every 1,000 workers receive lost-time injuries each year and an average of 4.4 are killed. There is an average of 18.5 days lost time for each 1,000 hours or 125 days worked. According to the United States Bureau of Mines Bulletins 292 (1926), 310 (1929), 320 (1930), 342 (1931), and 362(1932), the relative rating of Colorado as to accident frequency compared with 23 other metal-producing States were as follows:

Year	Rank in fatality rates	Rank in lost-time injury rates
1930	23	17
1929	24	19
1928	17	9
1927	24	7
1926	9	7

The only comparison the writers have found as to metal-mine severity rates is that of 52 metal mines competing in the National Safety Competition of 1930; according to Bureau of Mines Report of Investigations 3126 (1931) their average severity rate was 5.3 days lost per 1,000 hours of exposure or less than one third of the Colorado rate.

COLORADO WORKMAN'S COMPENSATION ACT

Important features of the Workman's Compensation Act of Colorado as amended in 1929 and 1931 include:

1. Administration of the act by an industrial commission.

2. Every employer of four or more employees (not including private domestic servants and farm and ranch laborers) is presumed to have accepted the provisions of the compensation act unless he has filed a notice in writing with the commission to the contrary.

3. An employer may secure compensation for his employees by insuring in the State Compensation Insurance Fund, by insuring with any authorized stock or mutual corporation, or by procuring a self-insurance permit from the commission.

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4. Every insurance carrier writing compensation insurance must write it at rates approved as adequate by the commission.

5. If an employer subject to the compensation act has allowed his insurance to terminate or has not complied with the insurance provisions of the act, an injured employee or his dependents if he is killed may claim compensation, and the amount of compensation or benefits is thereby increased 50 percent over that provided by the act.

6. Every employer is required to keep a record of all injuries, fatal or otherwise, received by his employees in the course of their employment and to report an accident to the commission within 10 days of its occurrence upon forms prescribed by the commission and containing such information as required by the commission.

7. Salaries and expenses of the State Compensation Fund are paid out of the earnings of this fund, but must in no case exceed 10 percent of the premiums written by the Fund during the preceding year.

8. Every employer must furnish such medical, surgical, nursing, and hospital treatment, medical, hospital and surgical supplies, crutches and apparatus as may be reasonably needed at the time of injury and thereafter during the disability, but not exceeding four months from the date of accident and $500 in value.

9. In case of death, the dependents receive 50 percent of the deceased employee's average weekly wage not to exceed a maximum of $14 per week or a minimum of $5 per week for a period not to exceed 6 years. Marriage or death of any dependent terminates the dependency, as does the reaching of age of 18 by a son or brother of the deceased. This amounts to a maximum death benefit of $4,375. Dependents not residents of the United States receive only one fourth of the amount provided for residents.

In case of temporary disability of more than 10 days duration, the employee receives 50 percent of his average weekly wages so long as such disability is total, not to exceed $14 per week or less than $5 per week unless his wages are less than $5 per week, in which case he receives the actual wage. No compensation is paid for the first 10 days of disability.

In case of permanent partial disability the injured employee receives in addition to compensation for temporary disability, compensation based on the importance of the member lost; thus for loss of 1 eye he receives 104 weeks compensation, for loss of leg at hip 208 weeks, and for loss of arm at shoulder 208 weeks.

In case of injury to the teeth of an employee he receives in addition to disability benefits dental treatment not to exceed $100 in value.

In case of permanent total disability, the award is 50 percent of the average weekly wage subject to maximum and minimum limitations already described, continuing to the death of the injured person.

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10. Compensation provided under the compensation act is reduced from the wilful failure of the employee to use safety devices provided by the employer, or from wilful failure to obey any reasonable rule adopted by the employer for the safety of the employee, or where injury results from intoxication of the employee.

11. The present (Feb. 1933) State Fund insurance rate is $4.27 per $100 of pay roll for Colorado metal mines. A 30 percent dividend return was made in 1932. The rate (Oct. 31, 1932) of private insurance companies for Colorado metal mines is $7.70 per $100 of pay roll, this being increased from a previous rate of $6.84.

The complete text of the workmen's compensation act of Colorado, obtainable from the Colorado Industrial Commission, Denver, should be referred to for fuller information.

MINE-ACCIDENT PREVENTION

A brief discussion of accidents classified according to causes is given in the foregoing pages of this report. It is evident that the provision of adequate protective equipment is not sufficient to prevent all accidents, and that proper supervision and discipline from the top of the company organization down is an essential factor for safe operation. A glance at the description of the various types of accidents furnishes the conviction that proper supervision supported by effective disciplinary measures might have prevented many of these accidents.

The burden of accident prevention rests with the management, who must stand solidly behind the safety movement. In addition to providing adequate supervision and discipline the company should show its desire for safety by proper safeguarding of mine surroundings and equipment, periodic inspections of equipment and operations, and general cleanliness and orderliness—in other words, good housekeeping. In the larger mines the men can be made safety-minded by means of publicity, instruction, bulletins, safety committees with propor departmental representation, and safety meetings. Officials and men should be required to familiarize themselves with and comply with state and company safety rules and practices. In small operations men can still comply with state rules and familiarize themselves by reading and discussion of safe practices. The man in charge of a small operation, say less than 25 men, can act as a safety committee of one toward accident prevention.

The writers have studied the problem of accident prevention in Colorado metal mines not only from the reports on accidents made to the Colorado Industrial Commission, but also by examination of some 30 Colorado metal mines. Recommendations have been made to the recent annual meetings of the Colorado Metal Mine Association, and a summary of substandard and dangerous conditions noted was made in a publication entitled "Safety and Compensation" published jointly in 1931 by the Colorado Metal Mining Fund, the Colorado Industrial Commission, and the Colorado Bureau of Mines.

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SUBSTANDARD CONDITIONS

Many of the substandard conditions published in the report mentioned still exist in some Colorado metal mines. They are, therefore, listed here as factors partly responsible for Colorado's high accident rate and factors which should be eliminated if this rato is to be substantially improved. They are as follows:

1. Miners were observed to delay or entirely neglect to take down loose rock in the back or hanging wall. Rock falls cause 18 percont of Colorado metal-mine accidents; the remedy is carefulness and discipline; the fault rests with the management as well as the miner.

2. Miners were observed to delay in cleaning down manways and raises after blasting or to neglect to do this work. Loose rock and debris over a man on a ladder is a double menace; this is again a matter of carefulness which should be enforced by proper supervision and discipline.

3. Ladderways traveled frequently by men were observed and traveled, extending 40, 60, and more feet vertically, or even leaning outward from the vertical, these ladderways having no intermediate platforms or landings or having inadequate platforms or landings. Doors are frequently not installed in sollars. Ladders were traveled having from one to four consecutive rungs missing; some laddors were insufficiently or insecurely fastened in place where ladder slippage would mean a probable fatal fall.

4. Winzes were observed without timbered collars.

5. Manways opening into the levels above were observed without protecting doors or covering.

6. Large abandoned stopes above traveled levels were observed with no protection afforded against possible loose rock. Abandoned stopes opening along traveled drifts were observed to be not railed off.

7. Open ore passes were observed to be not railed off or protected by grizzlies.

8. Use of insufficient platforms or of no platform on working floors of square-set stopes and in raises was observed. Instances of insufficient timbering and timbering of too light a nature were seen.

9. Dry drilling was noted in several mines; this is particularly dangerous in siliceous ground.

10. Men loading cars from chutes were seen taking unnecessary chances such as standing directly in front of the chute mouth while barring down "hung up" rock or ore.

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11. Many chute gates were of a type awkward to handle and not providing sufficient control where the ore might hang up temporarily and then come with a sudden rush.

12. Explosive boxes were seen being opened with a pick; wooden tools should be used.

13. Careless and rough handling of explosives was seen.

14. Instances of storage of boxes of explosive and capped fuse within a few inches of the rail were observed. Capped fuse was frequently seen stored within 12 feet of boxes of explosion. Boxes of explosive were found under loose rock with the top of the box removed. Capped fuse and explosive were even found in the same box in one instance. Detonators and explosives should always be stored a safe distance apart, both of them in closed rigid containers.

15. Overhead 440-volt power lines were observed less than 5 feet 9 inches above the rail, hence affording hazard of electrocution. In several instances electrical installations and wiring were substandard with respect to insulation, suspension, and guarding against man contact.

16. Old timber, powder boxes, paper and other flammable debris were observed piled random in crosscuts and wide spots without regard to fire hazard. A small timber fire may make sufficient smoke and carbon monoxide to imperil every man in the mine.

17. Surface shaft houses and other mining buildings which were not fireproofed were observed; many of these buildings were so located that a fire in them might imperil the lives of the men working in the mine. Because of connections underground and lack of fire doors, fires in buildings or abandoned properties in some cases might imperil the lives of men working in adjoining mines. In several cases fire doors were not provided at openings of working mines about which were wooden buildings, and in some cases the doors were in such location and of such construction that they might give only temporary protection before they were burned out.

18. In some cases an almost total lack of underground fire protection was noted and inadequate surface fire protection was also observed.

19. Mine locomotives were seen operating in some places where there was almost no man clearance and no refuge holes provided for men.

20. Much work is so scattered in old mines that men work with little supervision; this is particularly true of men working under the leasing system, who sometimes have little mining experiences.

21. Carbide is sometimes stored in too large quantities underground without regard to surroundings.

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22. Men were found working without eye protection at tasks involving definite hazards to the eyes. It is not sufficient to provide goggles; their use must be enforced. At some mines hard hats were not worn and protective shoes were practically unknown.

23. Lack of accident records classified as to causes was reported in several instances.

24. Lack of safety organization or safety meetings was noted at several mines.

The foregoing is not a complete list of substandard practices and conditions observed; it is desired to call attention, however, to the fact that many of them can be corrected by the operator or miner at little or no expense.

ACKNOWLEDGMENT

The writers wish to acknowledge the helpful assistance received, both in compiling this report and in interpreting the data therein, from the Colorado Industrial Commission and its officials and employees, particularly Thomas Annear, chairman; Mr. Redding, manager of the State Compensation Fund; and Mr. Smith, secretary; and also from John T. Joyce, Colorado State Commissioner of Mines.

APPENDIX

The following tables (1 to 8) give detailed figures on the cost, frequency, and severity of Colorado metal-mine accidents. The main facts disclosed by these tables have been given in this report.

Table 1. - Compensable accidents in Colorado metal mines, 1926 - 1930, inclusive

Year	Compensable accidents	Days lost	Compensation cost, all accidents	Medical cases reported	Medical cost of reported cases	Estimated total medical cost based on all accidents	Estimated total compensation and medical cost
1926	357	162,511	$198,412.27	138	$10,364.32	-	-
1927	386	243,551	177,460.24	160	13,924.38	-	-
1928	310	176,248	144,911.15	134	13,170.35	-	-
1929	337	204,883	160,992.96	193	17,210.20	-	-
1930	371	176,914	141,729.26	162	12,348.91	-	-
Total	1,761	964,107	817,305.88	787	1/66,017.96	2/$135,052.42	$952,558.30
Average	352.2 per year	192,821 per year	464.23 per case	-	-	76.69 per case	540.92 per case

1/ Actual medical cost of 787 cases. 2/ Calculated by estimating costs of fatalities, permanent disabilities, and temporary lost-time disabilities separately. See Table 5.

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Table 2. - Noncompensable accidents in Colorado metal mines, 1926 - 1930, inclusive

Year	Non-compensable accidents	All noncompensable accidents: Days lost	Medical cases reported	Medical cost reported cases	Estimated total medical cost	No-lost-time accidents: No lost-time accidents	Medical cases reported	Medical cost of reported cases	Estimated total medical cost
1926	619	1,568	383	$3,059.25	-	273	197	$1,420.10	-
1927	725	1,610	489	4,453.48	-	392	295	2,216.23	-
1928	724	1,581	465	3,531.00	-	370	263	1,697.75	-
1929	915	1,931	530	5,023.20	-	478	313	2,637.70	-
1930	766	1,468	401	3,565.75	-	436	255	1,914.95	-
Total	3,749	8,158	2,268	19,632.68	1/$32,452.79	1,949	1,323	9,886.73	2/$14,564.80
Average	749.8 per year	1,632 per year	-	-	8.66 per case	390 per year	-	-	7.44 per case

1/ Actual medical costs were available on 2,268 of the 3,749 cases reported; from these costs the total medical cost was calculated.

2/ Actual medical costs were available on 1,323 of the 1,949 cases reported; from these costs the total medical cost was calculated.

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Table 3. - Compensable accidents in Colorado metal mines, 1926 - 1930, inclusive showing causes, costs, and days lost

Cause	Cases	Days lost	Average days lost	Compensation cost	Average compensation cost	Medical, funeral, and hospital cost of reported cases	Medical, funeral, and hospital cases reported
Underground:							
1. Fall of roof or ore from roof or wall	324	202,520	625.06	$171,323.80	$528.78	$13,319.58	140
2. Rock or ore while loading at working face	117	47,932	409.68	26,068.32	222.81	2,320.80	39
3. Timber or hand tools	132	40,793	309.04	34,778.87	263.48	5,410.90	68
4. Explosives	46	125,643	2,731.37	182,433.37	3,965.94	3,233.14	25
5. Haulage	243	71,817	295.54	43,023.33	177.05	5,987.38	100
6. Falling down chute, raise or stope	105	114,825	1,093.57	71,839.63	684.19	5,043.62	58
7. Run of ore from chute or pocket	114	48,314	423.81	31,361.32	275.10	3,755.28	37
8. Drilling	137	26,979	196.93	35,291.51	257.60	4,643.66	53
9. Electricity	3	143	47.67	200.57	66.86	100.00	1
10. Machinery (other than locomotives or drills)	32	22,684	708.88	14,411.80	450.37	1,881.90	19
12. Suffocation from natural gases	2	90	45.00	147.14	73.57	122.70	2
14. Stepping on nails	8	1,165	145.62	1,064.22	133.03	988.05	5
15a. Handling materials (other than rock or ore)	25	8,331	333.24	16,389.31	655.57	765.10	11
15b. Other causes	27	15,323	567.52	26,990.77	999.66	817.64	9
Underground totals and averages	1,315	726,559	552.52	655,323.96	498.35	48,389.75	567

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Table 3. - Compensable accidents in Colorado metal mines, 1926 - 1930, inclusive, showing causes, costs, and days lost--Continued

Cause	Cases	Days lost	Average days lost	Compensation cost	Average compensation cost	Medical, funeral, and hospital cost of reported cases	Medical, funeral, and hospital cases reported
Shaft:							
16. Falling down shaft	2	49	24.50	$23.46	$11.73	$102.10	2
17. Objects falling down shaft	11	6,636	603.27	4,534.45	412.22	212.50	4
18. Breaking of cables	4	7,274	1,818.50	1,916.35	479.09	194.00	3
20. Skip, cage or bucket	34	49,378	1,452.29	29,637.02	871.68	2,782.30	23
21. Other causes	1	15	15.0	8.57	8.57	0	0
Shaft - Totals and averages	52	63,352	1,218.31	36,119.85	694.61	3,290.90	32
Surface:							
22. Mine cars, mine locomotive	43	9,077	211.09	6,265.15	145.70	702.40	18
23. Railway cars and locomotives	6	6,175	1,029.17	3,969.70	661.62	193.00	2
24. Run or fall of ore in or from ore bins	6	1,376	229.33	1,102.79	183.80	268.00	3
25. Falls of persons	85	13,714	161.34	19,042.49	224.03	2,498.48	38
26. Stepping on nail	10	1,995	199.50	1,572.91	157.29	367.25	6
27. Hand tools, axes, bars, etc.	50	7,993	159.86	7,567.74	151.35	1,781.97	26
28. Electricity	13	23,421	1,801.62	11,026.80	848.22	714.00	7
29. Machinery	45	27,000	600.00	16,815.92	373.69	1,748.29	16
30a. Handling materials	65	7,111	109.40	7,151.56	110.02	1,537.90	29
30b. Other causes	69	76,181	1,104.07	51,294.39	743.40	4,343.02	41
Surface totals and averages	392	174,043	443.99	125,809.45	320.94	14,154.31	186
No cause listed	2	153	76.50	252.62	126.31	183.00	2
Grand totals and averages	1,761	964,107	547.48	817,505.88	464.23	66,017.96	787

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Table 4. - Noncompensable accidents in Colorado metal mines, 1926- 1930, inclusive, showing causes, costs, and days lost

Cause	Cases	Days lost	Average days lost	No days lost time	Medical cases reported	Medical cost	Average medical cost
derground:							
1. Fall of rock or ore from roof or wall .	663	1,467	2.21	322	427	$4,083.80	$9.56
2. Rock or ore while loading at working face	271	488	1.80	155	142	966.15	6.80
3. Timber or hand tools	580	1,066	1.84	319	357	2,783.10	7.80
4. Explosives	13	45	3.46	5	4	26.50	6.62
5. Haulage	366	1,047	2.86	156	200	1,541.75	7.71
6. Falling down chute, raise or stope	114	357	3.13	45	61	611.50	10.02
7. Run of ore from chute or pocket ...	240	588	2.45	107	159	1,480.25	9.31
8. Drilling	475	731	1.54	307	345	2,728.40	7.91
9. Electricity	6	19	3.17	1	3	31.00	10.33
0. Machinery (other than locomotives or drills)	34	74	2.18	16	13	108.00	8.31
2. Suffocation from natural gases	12	12	1.00	10	8	33.50	4.19
4. Stepping on nails .	92	210	2.28	51	59	470.50	7.97
a. Handling materials (other than rock or ore)	72	209	2.90	35	37	305.90	8.27
b. Other causes	88	209	2.38	46	49	458.00	9.35
Underground totals and averages	3,026	6,522	2.16	1,575	1,864	15,628.35	8.38
aft:							
6. Falling down shaft.	2	12	6.00	0	0		
7. Objects falling down shaft	23	53	2.30	15	15	232.00	15.47
8. Breaking of cables.	1	4	4.00	0			
0. Skip, cage, or bucket	40	95	2.38	18	20	172.00	8.60
1. Other causes	6	15	2.50	4	5	34.50	6.90
Shaft totals and averages	72	179	2.49	37	40	438.50	10.96

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Table 4. - Noncompensable accidents in Colorado metal mines, 1923 - 1930, inclusive, showing causes, costs, and days lost--Continued

Cause	Cases	Days lost	Average days lost	No days lost time	Medical cases reported	Medical cost	Average medical cost
Surface:							
22. Mine cars, mine locomotives	51	191	3.75	17	34	462.50	13.60
23. Railway cars and locomotives	3	7	2.33	2	1	5.50	5.50
24. Run or fall of ore in or from ore bins	11	24	2.18	6	5	67.50	13.50
25. Falls of person ...	80	215	2.69	33	51	689.13	13.51
26. Stepping on nail ..	41	98	2.39	17	14	103.00	7.36
27. Hand tools, axes, bars, etc.	136	203	1.49	90	74	596.75	8.06
28. Electricity	14	31	2.21	4	9	99.50	11.06
29. Machinery	80	154	1.92	42	56	593.80	10.60
30a. Handling materials	170	324	1.91	96	82	631.20	7.70
30b. Other causes	61	192	3.15	29	35	280.95	8.03
Surface totals and averages	647	1,439	2.22	336	361	3,529.83	9.79
No cause listed	4	18	4.50	1	3	36.00	12.00
Grand total and averages	3,749	8,158	2.18	1,949	2,268	19,632.68	8.66

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Table 5. - Colorado metal-mine accidents, 1926 - 1930, inclusive, showing cost of fatal and permanent partial and total disability accidents

Year	Fatalities	Compensation cost	Medical, hospital, and funeral cost	Total cost	Permanent total disabilities	Compensation cost	Estimated medical and hospital cost of all cases	Estimated total cost
1926	13	$36,015.11	$3,210.10	$39,225.21	5	$105,907.50	-	-
1927	27	56,600.85	3,335.45	59,936.30	3	56,916.00	-	-
1928	17	43,310.08	2,379.00	45,689.08	3	51,980.58	-	-
1929	23	69,993.72	2,607.44	72,601.16	2	24,344.42	-	-
1930	16	40,094.45	1,974.26	42,068.71	2	31,864.00	-	-
Total 5 years	96	246,014.21	13,506.25	259,520.46	15	271,008.50	$4,644.56	$275,653.06
Average	19.2 per year	2,562.65 per case	140.69 per case	2,703.34 per case	3 per year	18,067.23 per case	309.64 per case	18,376.87 per case

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Table 5. - Colorado metal-mine accidents, 1926 - 1930, inclusive, showing cost of fatal and permanent partial and total disability accidents--Continued

Year	Permanent partial disabilities	Compensation cost	Estimated medical and hospital cost of all cases	Estimated total cost	Grand total	
					Cases	Estimated grand total cost
1926	41	$35,735.80	-	-	59	-
1927	45	47,279.54	-	-	75	-
1928	51	38,745.95	-	-	71	-
1929	43	50,730.13	-	-	68	-
1930	56	49,554.05	-	-	74	-
Total 5 years	236	222,045.47	$40,906.12	$262,951.59	1/ 347	$798,125.11
Average	47.2 per year	940.87 per case	173.33 per case	1,114.20 per case	69.4 per year	2,300.07 per case

1/ Actual medical costs were available on 220 of the 347 cases; from these costs the total cost was figured.

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Table 6. - Colorado metal-mine accidents, 1926 - 1930, inclusive showing all accidents by cause, percentage, and days lost

Cause	Cases	Per cent of total	Days lost	Average days lost
1. Fall of roof or ore from roof or wall	987	17.92	203,987	206.7
2. Rock or ore while loading at working face	388	7.04	48,420	124.8
3. Hand tools	712	12.93	41,859	58.8
4. Explosives	59	1.07	125,688	2,130.3
5. Haulage	609	11.05	72,864	119.6
6. Falling down chute raise or stope	219	3.97	115.182	525.9
7. Run of ore from chute or pocket	354	6.42	48,902	138.1
8. Drilling	612	11.11	27,710	45.3
9. Electricity	9	0.16	162	18.0
10. Machinery (other than locomotives or drills)	66	1.20	22,758	344.8
12. Suffocation from natural gases	14	0.25	102	7.3
14. Stepping on nail	100	1.81	1,375	13.8
15a. Handling materials (other than rock or ore)	97	1.76	8,540	88.0
15b. Other causes	115	2.09	15,532	135.1
16. Falling down shaft	4	0.07	61	15.2
17. Objects falling down shaft	34	0.62	6,689	196.7
18. Breaking of cables	5	0.09	7,278	1,455.6
20. Skip, cage, or bucket	74	1.34	49,473	668.6
21. Other causes	7	0.13	30	4.3
22. Mine cars, mine locomotives	94	1.71	9,268	98.6
23. Railway cars and locomotives	9	0.16	6,182	686.9
24. Run or fall of ore in or from ore bins	17	0.31	1,400	82.4
25. Falls of persons	165	2.99	13,929	84.4
26. Stepping on nail	51	0.93	2,093	41.0
27. Hand tools, axes, bars, etc.	186	3.38	8,196	44.1
28. Electricity	27	0.49	23,452	868.6
29. Machinery	125	2.27	27,154	217.2
30a. Handling material	235	4.26	7,435	31.6
30b. Other causes	130	2.36	76,373	587.5
No cause listed	6	0.11	171	28.5
Total	5,510	100.00	972,265	176.5

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Table 7. - Accident frequency and severity rates in Colorado metal mines, 1926 - 1930, inclusive

Year	Days employment 1/	Fatal accidents	Permanent total disabilities	Permanent partial disabilities	Temporary disabilities: Over 10 days lost time	Temporary disabilities: One to 10 days lost time	No-lost-time accidents 2/	Frequency rate: Killed per thousand 300-day workers	Frequency rate: Lost-time nonfatal injuries per thousand 300-day workers	Total lost-time accidents per thousand 300-day workers	Total all accidents per thousand 300-day workers	Severity rate: Days lost from accidents	Severity rate: Days lost per 1,000 hours exposure 3/
1926	1,269,246	13	5	41	298	346	273	3.07	163.1	166.2	230.7	164,079	16.2
1927	1,210,315	27	3	45	311	333	392	6.69	171.5	178.2	275.4	245,161	25.3
1928	1,607,723	17	3	51	239	354	370	3.18	121.0	124.2	193.4	177,829	13.9
1929	1,467,814	23	2	43	269	437	478	4.70	153.6	158.3	255.9	206,814	17.6
1930	1,000,669	16	2	56	297	330	436	4.80	205.4	210.2	340.9	178,382	22.3
5-yr. Total	6,551,767	96	15	236	1,414	1,800	1,949	4.40	158.7	163.1	252.3	972,265	18.5

1/ Annual reports of State Metal Mine Commissioner, but deductions made in 1926 and 1927 for Moffat (railroad) tunnel.
2/ Not figured into frequency rate.
3/ Each working day estimated as 8 hours.

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Table 8. - Scale of time losses for weighing industrial accident disabilities so as to show severity of accidents, according to the U. S. Bureau of Mines

Nature of injury	Degree of disability in per cent of permanent total disability	Days lost
ıth	100	6,000
ːmanent total disability	100	6,000
ı above elbow, dismemberment	75	4,500
ı at or below elbow, dismemberment	60	3,600
ıd, dismemberment	50	3,000
ımb, any permanent disability of	10	600
ː 1 finger, any permanent disability of	5	300
ːingers, any permanent disability of	12½	750
ːingers, any permanent disability of	20	1,200
ːingers, any permanent disability of	30	1,800
ımb and 1 finger, any permanent disability of	20	1,200
ımb and 2 fingers, any permanent disability of	25	1,500
ımb and 3 fingers, any permanent disability of	33-1/3	2,000
ımb and 4 fingers, any permanent disability of	40	2,400
; above knee, dismemberment	75	4,500
; at or below knee, dismemberment	50	3,000
ɔt dismemberment	40	2,400
ːeat toe, or any 2 or more toes, any permanent disability of	5	300
ːoe, other than great toe, any permanent disability of	0	-----
ːye, loss of sight	30	1,800
ːh eyes, loss of sight	100	6,000
ːar, loss of hearing	10	600
ːh ears, loss of hearing	50	3,000

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